STUDY ON BEHAVIOUR OF DIFFERENT SHAPES AND LOCATIONS OF OPENING ON REINFORCED CONCRETE BEAM BY USING ANSYS

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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STUDY ON BEHAVIOUR OF DIFFERENT SHAPES AND LOCATIONS OF OPENING ON REINFORCED CONCRETE BEAM BY USING ANSYS

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ABSTRAK

Pada masa kini, pembinaan bangunan moden memerlukan saluran perkhidmatan dan paip untuk menampung perkhidmatan penting seperti penghawa dingin, elektrik, paip air, taburan kebakaran dan lain-lain utiliti. Kewujudan pembukaan web pada rasuk R.C akan mempengaruhi kelakuan keseluruhan balok dan akhirnya akan menjejaskan kebolehkerjaan dan keadaan akhir bangunan. Tujuan penyelidikan ini adalah untuk menentukan kesan pelbagai lokasi dan bentuk pembukaan rasuk RC dari segi beban muktamad, pesongan dan corak retak. Kajian ini adalah mengenai analisis unsur terhingga pada rasuk dengan pembukaan web dengan ujian lenturan 4 mata dengan menggunakan perisian ANSYS 12. Terdapat sejumlah 6 model dianalisis dalam kajian ini. Model rasuk R.C pepejal, SB digunakan sebagai model kawalan, yang merupakan rasuk konkrit bertetulang tanpa sebarang pembukaan. Terdapat 5 model dengan pembukaan dianalisis dan terdapat perbezaan dalam bentuk pembukaan dan lokasi pembukaan. Lokasi bukaan dibahagikan kepada 240mm, 480mm dan 910mm dari pinggir balok yang dilabelkan sebagai BO1, BO2 dan BO3 masing-masing. Selain itu, bentuk pembukaan dikategorikan sebagai bulat, persegi dan segi empat tepat sambil mengekalkan kawasan dan lokasi pembukaan tidak berubah. Pembukaan persegi ditetapkan sebagai BO4 dan pembukaan segi empat tepat ditetapkan sebagai BO5. Dengan analisis, pesongan terbesar berlaku pada pertengahan rasuk. Selain itu, dalam tempoh beban muktamad, pembukaan yang terletak berhampiran sokongan menunjukkan pengurangan terbesar dalam beban muktamad, 55.66% membandingkan dengan rasuk pepejal manakala pembukaan pekeliling memberi nilai maksimum pesongan berbanding dengan bukaan persegi dan pembukaan segi empat tepat.

ABSTRACT

Nowadays, the construction of modern building requires services ducts and piping in order to accommodate essential services such as air-conditioning, electricity, water piping, fire sprinkle and others utility. The existence of a web opening on R.C beam will affect the overall behaviour of the beam and will eventually affect the serviceability and ultimate limit state of the building. The aim of this research is to determine the effect of various locations and shapes of opening of RC beam in term of ultimate load, deflection and crack pattern. The study is about the finite element analyses on beam with webs opening with 4 point bending test by using ANSYS 12 software. There are total of 6 models were analysed in this study. A solid R.C beam model, SB was used as controlling model, which is a reinforced concrete beam without any opening. There are 5 models with openings were analysed and there were different in the shape of opening and the location of the opening. The location of the openings distinguished into 240mm, 480mm and 910mm from the edge of beam labelled as BO1, BO2 and BO3 respectively. Moreover, the shapes of opening are categorized as circular, square and rectangular while keeping the area and location of opening unchanged. The square opening is designated as BO4 and the rectangular opening is designated as BO5. By the analysis, the greatest deflection is occurring in the mid-span of the beam. Moreover, in the term of ultimate load, opening that located near support show the greatest reduction in ultimate load, 55.66% comparing with solid beam whereas circular opening gives the greatest value of deflection compare with square opening and rectangular opening.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

RC beam	Reinforced Concrete beam

CHAPTER 1

INTRODUCTION

1.1 General

In recent decade, the common material for construction process is reinforced concrete beam. Reinforced concrete beam was used to carry the load from slab to the wall. As the construction of modern building developing and advancing with continuous increasing demands of community, a network of pipes and ducts was necessary to accommodate essential services such as conduits, water and drainage pipes, ventilation system, air conditioning and network system access. Due to aesthetic reasons, these pipes and ducts in traditional building are located below the soffit of beam and it is covered by a suspended ceiling. It was created a dead space between the ceiling level and the bottom of beam. To avoid the creation of dead space, a reinforced concrete beam with the web opening was the only solution since the pipes and ducts were passed through the opening on beam and reduced the overall height of the building which leads to an economical design. From the perspective of cost savings, the impact of opening on small building beams is small, but it will have a huge impact on high-rise buildings.

Research for the beams with an opening started from 1960 and most of the research is about the reinforced concrete beam with web opening (Mansur MA, 1998). The presence of openings will transformed simple beam behavior into a more complex behavior, as we induced a sudden change in the cross sectional dimension of beam.. The ultimate strength, crack width shear strength and stiffness may also be seriously affected (Mansur MA, 2006). Last but not least, due to abruptly changed in the cross sectional of beam, the shear cracks end will formed around the region of the openings and allowable deflection of R.C beam decreased

According to Prentzas (1968), the shapes of openings are circular, rectangular, diamond, triangle, trapezoidal and even irregular shapes. However, the most common shapes of opening in construction industries were rectangular and circular. A rectangular opening usually provided for the air-conditioning channel while a circular opening was used to provide services such as water piping, network, fire sprinkle and electrical conduits. With regards to the size of openings, many researchers used the terms ‘‘small’’ and ‘‘large’’ without drawing any clear-cut differentiate line. Small openings are defined as those which were circular, square or nearly square in shape (Mansur MA, 1998). According to Somes and Corley (1974, when its diameter exceeds 0.25 times the depth of the web), a circular opening may be considered as large. In terms of opening position, Mansur and Tan (2006) stated that location of web openings as; the opening is preferably flush with the flange for ease of construction. Openings are commonly placed at mid-depth of the section for the case of rectangular beams. Openings should not be located closer than one half of the beam’s depth D to the supports.

In this study, it aimed to conduct simulation on the behavior of the reinforced concrete beam with different shapes and locations of opening by using ANSYS 12.0 computer program to check out ultimate load, mid-span deflection and crack pattern of the beam with opening. The result and the finding in this study might be able to help the designer to design the building with a more economical method or design.

1.2 Problem Statement

Nowadays, the construction of modern building requires services ducts and piping in order to adapt to basic services such as air-conditioning, electricity, water piping, fire sprinkle and others facilities. These pipes and duct were usually placed beneath the concrete beam and thus they created dead load on the structural member as they designed to have longer distance to reach the designated place. However, concrete beam with opening was the solution by giving a compact design for the structural while decreasing the dead load on the building. For aesthetic purpose, RC beam may need to design with an opening.

The provision of a web opening on R.C beam affected the overall behaviour of the beam and will eventually affected the serviceability and ultimate limit state of the

building. R.C beam with opening will be experiencing the reduction of ultimate load that will lead to beam failure. Square opening may advance to high stress concentration at the corners of opening (M.A. Mansur and Tan 2006). Furthermore, R.C beam with opening will reduced stiffness of beam and increased deformation under service loading (Mansur M A, 2006). Last but not least, the shear cracks tend to formed around the region of the openings and allowable deflection of R.C beam was decreased (M.A. Mansur and Tan 2006). Figure 1.1 and Figure 1.2 showed the beam with square opening and circular opening respectively.

Figure 1.1 Beam with square opening

Source: Mansur M A, 2006

Figure 1.2 Beam with circular opening

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